7. EDUCATION AND PUBLIC OUTREACH

The Laboratory for Atmospheres actively participates in NASA's efforts to serve the education community at all levels and to provide information to the general public. The Laboratory's educational outreach component is consistent with the Agency's objectives to enhance educator knowledge and preparation, supplement curricula, forge new education partnerships, and support all levels of students. Laboratory activities include continuing and establishing collaborative ventures and cooperative agreements; providing resources for lectures, classes, and seminars at educational institutions; and mentoring or academically-advising all levels of students. Through our public outreach component, we seek to make our scientific and technological advances broadly accessible to all members of the public and to increase their understanding of why and how such advances affect their lives.

Interaction with Howard University and Other Historically Black Colleges and Universities

A part of NASA's mission is to initiate broad-based aerospace research capability by establishing research centers at the nation's Historically Black Colleges and Universities (HBCUs). The Center for the Study of Terrestrial and Extraterrestrial Atmospheres (CSTEA) was established in 1992 at Howard University (HU) in Washington, D.C., as a part of this initiative. The Laboratory for Atmospheres started its collaboration with CSTEA in the second 5-year period of NASA funding. It is the goal of NASA and mission of CSTEA to establish at Howard a self-supporting, world-class facility for the study of terrestrial and extraterrestrial atmospheres, with special emphasis in training African Americans in aerospace sciences and engineering.

The Laboratory continues its research and educational activity with Howard University's CSTEA program. A Technical Review Committee site visit has been held yearly to evaluate the CSTEA program, to make recommendations for the program's research and collaborative interactions with the Laboratory, to help the program with its strategic planning for future growth, and to help the program develop new funding sources. The Laboratory works closely with CSTEA faculty to promote the Howard University Program in Atmospheric Sciences (HUPAS). HUPAS is the first MS- and PhD- granting program in atmospheric sciences at an HBCU and the first interdisciplinary academic program at Howard University. Scientists from our Laboratory contribute to the HUPAS program as lecturers, advisors to students, and adjunct professors teaching some of the courses.

The Laboratory continues its enthusiastic support for the Goddard Howard University Fellowship in Atmospheric Sciences (GoHFAS) program. GoHFAS was established in 1999 to broaden and strengthen the research and educational opportunities of underrepresented minorities. The students attend a summer program at Howard University where they engage in research with mentors at HU, GSFC or NOAA. They attend a for-credit class in atmospheric science and a technical writing and presentation class. They receive fellowships at their home institutions during their senior year and are given an opportunity to come to HU during the winter break to continue their research. Six of the eight students from the first year of the program are now attending graduate school. Five of them are in the HUPAS program at HU. Four of the eight students from the second year have applied to Howard University.

The Laboratory hosted two faculty members on sabbatical from Howard University. A recent HU graduate is a new member of the Laboratory's Atmospheric Chemistry and Dynamic Branch and is pursuing his doctoral degree in the chemistry department while contributing to the research of the Laboratory.

Graduate Student Summer Program

The Laboratory for Atmospheres participated in a program administered by the Universities Space Research Association, in collaboration with the Goddard Space Flight Center's Earth Sciences Directorate. This program offers a limited number of graduate student research opportunities each summer. The program is designed to stimulate interest in interdisciplinary Earth science studies by enabling selected students to pursue specially tailored research projects in conjunction with Goddard scientific mentors. This program is now administered by the GEST Center. For further information, consult the World Wide Web (http://www.umbc.edu/gest/) under Student Opportunities.

University Education

At the university level, Laboratory scientists have taught undergraduate and graduate courses at universities, given seminars and lectures, participated in mentoring teachers and students under a variety of GSFC programs, and advised degree-seeking students. Four Laboratory scientists supervised undergraduate students and twenty-one supervised graduate students. Twenty-two Laboratory scientists have official affiliations (i.e. adjunct or visiting professor) with a university and fourteen regularly teach university-level courses.

Our scientists are involved as teachers in a variety of other settings. In a venture with other Goddard Laboratories, our scientists participated in delivering an MIT course for credit on the subject of Techniques in Remote Sensing. This course for MIT students took place during the winter semester break 1999-2000. The course was an Independent Activity Period course (IAP) during which students spent a week at Goddard and a week at MIT. The Laboratory presented lectures for 1 1/2 days during this seminar series. Each year our Laboratory hosts a visit of the AMS Fellowship winners, who are treated to informal lectures to acquaint them with the breadth of our research.

Laboratory scientists mentored five undergraduate students and nine graduate students during the summer of 2000 through various programs. Additionally, the Code 910/970 Summer Institute on Atmospheric and Hydrospheric Science brought about 15 undergraduate students to Goddard for two months of intensive research. Some of the students return to the Laboratory to work on other programs, and some are mentored by Laboratory scientists for their thesis work at their home institutions.

K–12 Education

Laboratory staff participated in K–12 education in a variety of ways. Laboratory scientists routinely presented lectures and demonstrations to K–12 schools and youth groups to help develop an early interest in science. Many Laboratory scientists have also mentored students in grades K–12. The Eleanor Roosevelt High School Science and Technology Internship Program enabled high school students to perform research on mesoscale atmospheric processes under the mentorship of Laboratory scientists. This program exemplifies a unique three-way partnership between the Laboratory, its contractors, and Eleanor Roosevelt High School. Members of the Laboratory served as judges for local science fairs and made presentations at High School Career Days to foster interest in NASA-related research. Additionally, Laboratory scientists continue to

mentor K–12 students. One Laboratory scientist was awarded Director's Discretionary Funding (DDF) for FY2000 for outreach related to Girl Scouts of Maryland and Earth science education. Another scientist volunteered and served as a judge for Goddard's "Virtual Science Fair," in which high school students submit reports on their research projects to Goddard by e-mail. Goddard scientists then e-mail advice back to them and, ultimately, judge the merit of their final work. One scientist worked with 7th grade students at St. Hugh's on "Seek Out Science," a project sponsored by ABC-TV Channel 7. This educational outreach teaches students how many of us chose our scientific careers and what steps we took to achieve our positions. Students also learn about data assimilation as a science and as a NASA endeavor.

In the areas of curriculum development and educator training, the Laboratory played a significant role in 2000. Several Laboratory scientists served on panels for local school districts in Prince George's County and Montgomery County to assist in developing new curricula. As a result, Earth science material has been or will be included as part of an enhanced science program at several area schools.

Public Outreach

Informing the public of how their tax dollar investments are working for them within the Laboratory is a critical subset of the Center and Agency public outreach mission. Laboratory scientists, working with other Laboratories at Goddard and outside institutions, have passed their knowledge and interest in Earth and space science to the general public via public information and education programs.

TRMM continues its comprehensive Education/Outreach program, in which Laboratory personnel are funded by the DDF to promote TRMM science to the public. This project develops outreach strategies for TRMM science and technology. These strategies include the development of broadcast visuals and educational curriculum focusing on the Tropical Rainfall Measuring Mission. These packages are available on the TRMM Web site (http://trmm.gsfc.nasa.gov/) and have been reviewed as a part of the ESE Education product review. They are currently under revision. TRMM scientists regularly appear on major media outlets (Earth and Sky Radio, CBS, NBC, ABC, and CNN) in support of the mission. In addition, Laboratory personnel have spoken at and conducted several outreach workshops in support of TRMM. The TRMM DDF principal investigator met with representatives of the African Technology Development Program and Howard University to discuss how TRMM science and resources could be useful in African countries. Further correspondence is anticipated.

The TRMM DDF Education and Outreach study has led to a feature story entitled *Seeing into the Heart of a Hurricane.* The story is available in the features section of the Earth Observatory Web site, http://earthobservatory.nasa.gov/, and features information and data from TRMM.

In addition to TRMM, Laboratory science stories routinely achieved major media exposure. The Goddard Public Affairs Office estimates that 50 million viewers tuned in to Laboratory-related science news in 2000. The Laboratory's scientists, images, and animations have appeared in the media, including TV segments with ABC's Peter Jennings and NBC's Tom Brokaw, and top billing of Goddard and NOAA images of hurricanes in *Time*, *Life*, and the covers of *Popular Science*, *Newsweek*, *Der Spiegel*, *National Geographic*, and *The Weekly Reader*. Four Laboratory scientists were featured in popular radio programs for public education, reaching a combined audience of more than 2 million listeners. They discussed subject matter related to ozone, global warming, and clouds. Also, Laboratory members frequently write invited popular articles; e.g., for the *Encyclopedia for Atmospheric Sciences*.

The Laboratory's presence in the media will likely expand due to new initiatives established in 1999 and continued into 2001. Collaboration with the Discovery Channel was initiated with Total Ozone Mapping Spectrometer Camera (TOMS-CAM) to raise awareness about atmospheric ozone issues. Various projects are in development to release TRMM, TOMS, and AVHRR products to the public through The Weather Channel. Two groups within the Laboratory were awarded DDF resources to produce a documentary on ozone and to develop a presentation for popular weather broadcasters. A Laboratory scientist has an Education DDF proposal in collaboration with Cindy Howell of Goddard PAO to fund a team of scientific journalists to put together a prospective story for a possible ozone documentary that could be sold to one of the educational TV shows like NOVA.

Laboratory efforts were not limited to formal outreach outlets (e.g. media). Several informal public outreach venues were utilized. Laboratory staff created a permanent display on the 3-dimensional temperature structure of the Earth for the GSFC Visitor Center. The TRMM Office provided a booth for visiting teachers. Laboratory scientists furnished input to the Mad Scientist Network, a group based at Washington University in St. Louis that answers questions submitted to them by students all over the world. Our scientists also contributed to Goddard Scientific Visualization Studio efforts to collaborate with the Smithsonian Institution, the American Museum of Natural History, Disney World EPCOT, and the White House in communicating scientific discoveries to the public.

GOES Web Server

This Web server continues to provide GOES images on-line, including full-resolution images of all sectors of the United States for the most recent two days. In addition, there are extensive scrapbooks of digital movies and pictures of important weather events observed by the GOES-8 and GOES-9 satellites since they were launched in 1994 and 1995, respectively. The Remote Sensed Data (RSD) server (http:rsd.gsfc.nasa.gov) has been judged by NASA-HQ to be one of the 20 most popular NASA Web sites during the year 2000. The science administrator of RSD supplies GOES-derived high-quality graphics and severe storm animations to the Visualization Analysis Laboratory (VAL), to GSFC Public Affairs Office (PAO), and directly to the public via the Internet. During active hurricanes, the GOES section of the RSD Web server is accessible to the general public.

EOS Terra Outreach Synopsis

Under the direction of Yoram Kaufman (Code 913), Claire Parkinson (Code 971), and David Herring (Code 913), a coordinated effort is underway to foster greater cooperation and synergy among various outreach groups within the EOS community. As such, each of the activities described below receives contributions from various persons strategically located in different organizations and/or codes within the community.

The Terra Project Science Office has produced thousands of copies of a Terra mission overview brochure. The layout and design of the brochure, as well as funding for its printing, came from Code 900. Additionally, this brochure, as well as many more images, animations, and information, is available on the Terra Web site (http://terra.nasa.gov/), which is also maintained by the Terra Project. The Aqua project scientist and outreach scientist are also developing an EOS Aqua overview brochure.

The Terra and Aqua project teams created NASA's Earth Observatory Web site (http://earthobservatory.nasa.gov/). This Web environment is the NASA Web portal where the general public goes to learn about the Earth. It showcases new images and science results from

EOS missions. The focus in its first year of operation was Sea-viewing Wide Field-of-View Sensor (SeaWiFS), TRMM, Landsat-7, SeaWinds, and Terra. All resources produced for the Earth Observatory are freely available for use by the EOS community, museums, educators, public media, regional "stakeholders," environmental awareness groups, and interested members of the general public. While leadership for this site resides in Code 913, significant contributions to its development come from Codes 900, 902, 912, 921, 922, 923, 935, 971, and 3200 at the Jet Propulsion Laboratory, as well as the American Museum of Natural History and East Carolina University.

To provide overarching guidance and review for the Terra outreach activities, as well as to flag mature new science results ready for public release, an Executive Committee for Science Outreach (ECSO) continues to operate. This committee is chaired by Dr. V. Ramanathan, of the Scripps Institute's Center for Clouds, Chemistry, and Climatology. The purpose of this committee is to "harvest" new Terra science results that are ready for public release, as well as to help temper the presentation of new results with respect to socio-political implications they may have.

Finally, the Terra Project formed a Rapid Response Network to meet the public media's requirements for quick access to satellite imagery relevant to, newsworthy Earth events (e.g., severe storms, floods, El Niño, volcanic eruptions, wildfires, etc.). The Network is headed by David Herring (Code 913), assistant Terra project scientist. After launch, this network will enable us to access and produce remote-sensing imagery over targets of interest within hours to days after acquisition.

The Terra outreach group, under David Herring, worked with Ron Erwin (GSFC Code 100 Education Office) to launch the Terra Engineering Competition, which was open to high school students throughout Maryland. The competition was sponsored and promoted jointly by the Baltimore Museum of Industry, Towson State University, and NASA GSFC. The competition involves high school students grappling with and proposing solutions to a real-world problem that Terra engineers are working on. The competition began in mid-December 2000. We hope to stimulate other NASA centers and affiliated agencies to replicate the competition for their respective states, to get broader exposure for the mission.

Three major outreach Web sites are (1) the Terra homepage (http://terra.nasa.gov/), (2) the Earth Observatory (http://earthobservatory.nasa.gov/), and (3) the Visible Earth (http://visibleearth.nasa.gov/). The Terra homepage was published in February 1999, and since December of that year (when the mission launched), the site has received 1.8 million page views. The Earth Observatory first published on April 29, 1999, has received more than 6 million page views, averaging currently about 35,000 per day. The Visible Earth published on August 17, 2000, has already received about 2.7 million page views. The purpose of the Visible Earth site is to provide access to THE SUPERSET of all Earth science images, animations, and data visualizations produced by NASA for public release.

EOS Aura Education and Public Outreach Synopsis

The Laboratory for Atmospheres has responsibility for conducting the Education and Public Outreach program for the EOS Aura mission. Aura's Education and Public Outreach program has four objectives. The first objective is to educate students about the role of atmospheric chemistry in geophysics and the biosphere. The second objective is to enlighten the public about atmospheric chemistry and its relevance to the environment and their lives. The third objective is to inform geophysics investigators of Aura science, and thus enable interdisciplinary research. The final objective is to inform industry and environmental agencies of the ways Aura data will

benefit the economy and contribute to answering critical policy questions regarding ozone depletion, climate change, and air quality.

To accomplish these objectives, the Laboratory has partnered with several institutions which have established infrastructures that reach large audiences in the areas of formal and informal education. The GLOBE program and the American Chemical Society (ACS) will carry out formal EOS Aura education outreach effort.

GLOBE is a worldwide network of students, teachers, and scientists working together to study and understand the global environment. Students and teachers from over 9,500 schools in more than 90 countries are working with the science community to learn more about the environment by making observations at or near their schools and reporting their data through the Internet. A protocol is being developed for students to measure UVB and overhead aerosols in collaboration with Aura research. The protocol will help students understand the implications of ozone and aerosol changes and their relationship to incident UVB. These data could also be valuable for validating Aura data, which takes comparable measurements from orbit. Since the Aura mission involves Partners from Europe, their Education and Public Outreach programs will also support the GLOBE international components.

The American Chemical Society (ACS) distributes its teaching magazine, *ChemMatters*, to 20,000 high school teachers. Over the next three years, the ACS will produce four issues of *ChemMatters* highlighting topics related to atmospheric chemistry, including space-flight technology, remote-sensing methods, ozone and climate observations, and forthcoming results from Aura measurements.

Our outreach to the general public will also include an exhibit at the Smithsonian's National Museum of Natural History. The museum has millions of visitors per year. Our exhibit will include a large display that illustrates the connections among land, ocean, and atmosphere. The exhibit will also include an interactive module that deals with Aura's three main science questions. The Laboratory's Visualization Analysis Laboratory (VAL) will develop the digital interactive displays. The museum will also develop a tool kit that will allow the display to be portable, and thereby, available to other museums in the US and abroad.

NASA/NOAA: Earth Science Electronic Theater 2000

The NASA/NOAA Earth Science Electronic Theater (E-Theater) uses interactive computer-driven displays at near-IMAX size to deliver a powerful tool for promoting Earth science. Scientists from the various Earth science disciplines work directly with the Visualization Analysis Laboratory (VAL) team to develop scientifically accurate visualizations. The E-Theater takes on new dimensions each time another scientist speaks to imagery designed and assembled in support of their area of expertise. E-Theater visualizations are rendered at High Definition TV (HDTV) quality, the highest resolution possible. The visualizations can be used in a host of other applications (i.e. National Television Standards Committee (NTSC) TV, QuickTime movies, Web graphics, etc.). QuickTime versions of each E-Theater visualization will be added to the E-Theater Web page (http://Etheater.gsfc.nasa.gov/index.html/) along with an explanation of the scientific significance and the origin of the data.

Using advanced computer technology and a large, panoramic projection screen, the E-Theater allows the presenter to interactively manipulate imagery and data animations. The impressive scale achieved by the wide E-Theater display contributes to a unique audience experience. Furthermore, these unique capabilities allow for spontaneous speaker/audience interactions.

Visualizations produced by our Laboratory's VAL, as well as other Goddard and NASA groups using NASA, NOAA, ESA, and NASDA Earth science data sets continue to be shown around the world using new display technologies. The Electronic Theater has been presented at universities, high schools, museums, and government laboratories to scientists and the general public. The E-Theater traveled to South Africa in support of the Safari 2000 Terra ground-truth experiment. In October, the E-Theater made a tour of New Zealand, Australia, and numerous other countries.

We continue to demonstrate methods for visualizing and interpreting immense HyperImage remote-sensing data sets and 3-dimensional numerical models. We call the data from many new Earth-sensing satellites: *HyperImage* data sets, because they have such high resolution in the spectral, temporal, and spatial domains. The traditional numerical spreadsheet paradigm has been extended to develop a scientific visualization approach for interactively processing HyperImage data sets and 3-D models. The advantages of extending the powerful spreadsheet style of computation to multiple sets of images and organizing image processing were demonstrated using the Distributed Image SpreadSheet (DISS). The DISS is being used as a high performance testbed application for the Next Generation Internet (NGI).

Museum Support

The Visualization Analysis Laboratory, VAL, actively works with several museums in creating new, innovative Earth science displays. A short list of some of these museums include the Smithsonian's National Museum of Natural History, the National Air and Space Museum, the American Museum of Natural History in NY, the Virginia Science Center, and the Houston Museum of Natural History. In conjunction with large museums, we are developing science presentations that will be made accessible and available to smaller museums.

One successful museum activity is the **"**Earth Today" exhibit. This exhibit evolved from an earlier Smithsonian exhibit, the "HoloGlobe." The Earth Today is a permanent exhibit in the National Air and Space Museum. It contains all of the original information contained in the "HoloGlobe" exhibit, and it has expanded the focus to include near-real-time data displays. These near-real-time data presently include global cloud cover, global water vapor, sea surface temperature, sea surface temperature anomalies, biosphere, and earthquakes. VAL personnel continue to actively promote advancements in this exhibit. These refinements include improved computer coding; new, high-resolution data sets (such as products from TRMM, TOMS, Terra and in the future, Aqua); a new version of Earth Today that will run on many mid-level PC's; and a version that will run on the Web.

Another effort is "Global Links." Global Links is an exhibition in the planning phase at the Smithsonian National Museum of Natural History. This exhibit will feature the four main Earth science spheres: atmosphere, biosphere, hydrosphere, and geosphere. The exhibit will focus on these different systems and explain what we know about the interdependency and delicate balance among these systems. VAL staff worked closely with the museum and NASA scientists to develop the initial concepts used in this exhibit. VAL personnel continue to work with the museum in refining those concepts. The Global Links exhibit provides the perfect opportunity to develop strong content to explain Earth science concepts.